



Dr. Raju Namburu
Computational Sciences Campaign
U.S. Army Research Laboratory

Theory

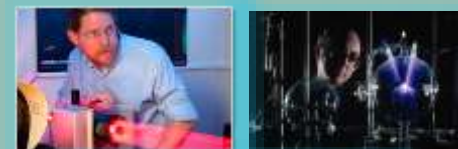
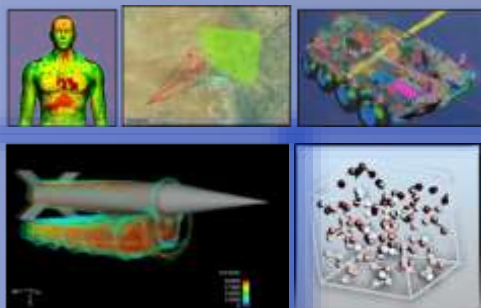
Theory embodied in
computation

Hypotheses
tested through
experiment



SCIENTIFIC METHODS

Scientific
Discovery
and
Innovation



Computation complements experiment

Computation

Experiment



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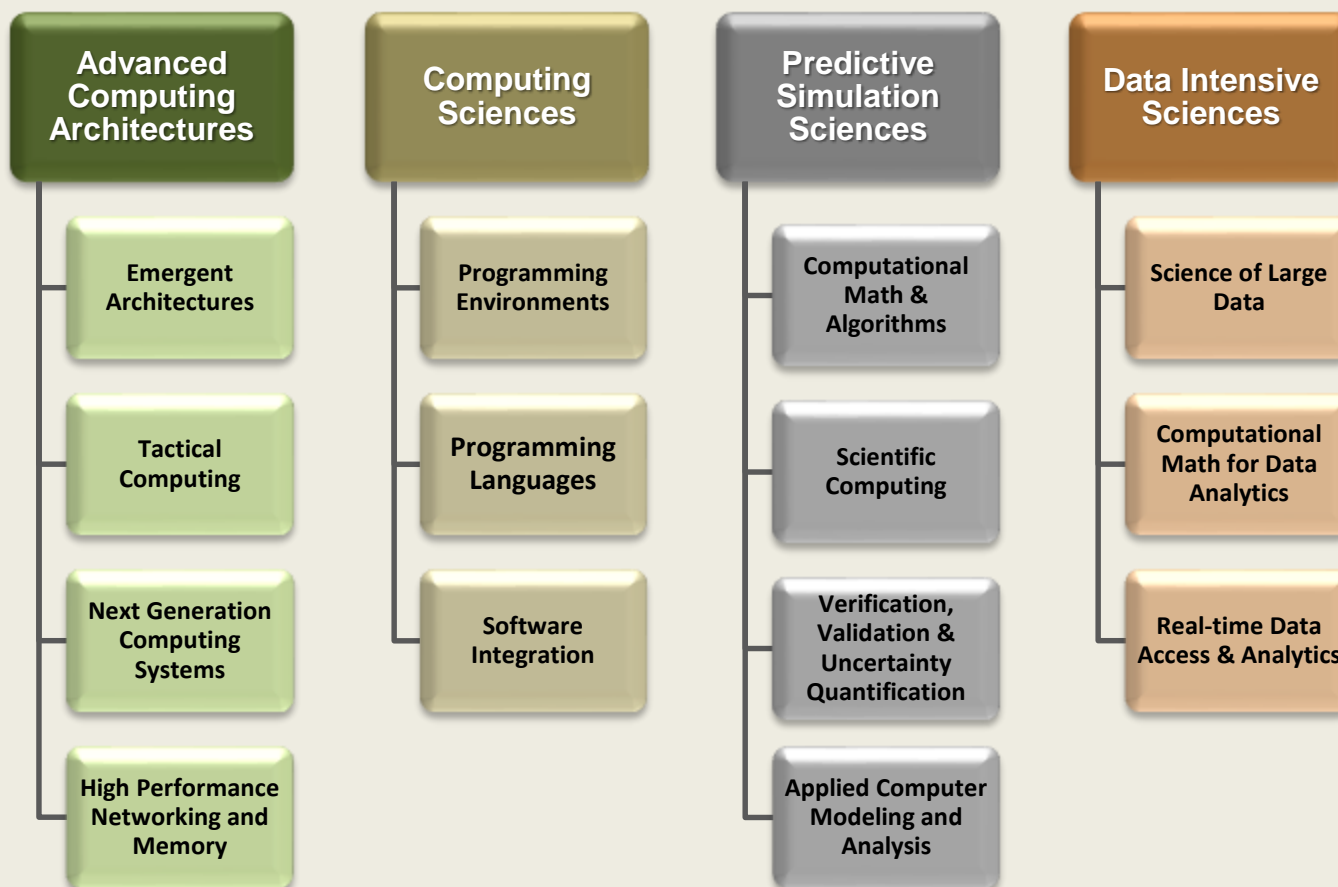
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Computational Sciences Campaign



Vision

Basic and applied research in computational sciences exploiting advanced computing to maintain the superiority of Army materiel systems and enable land power dominance.





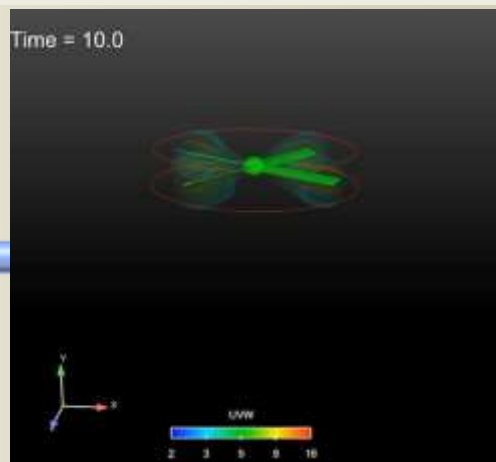
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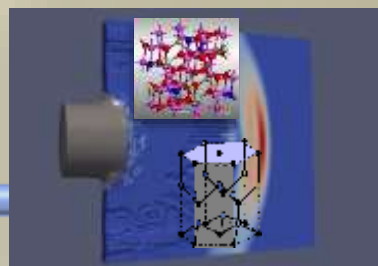
Cross Cutting Campaign



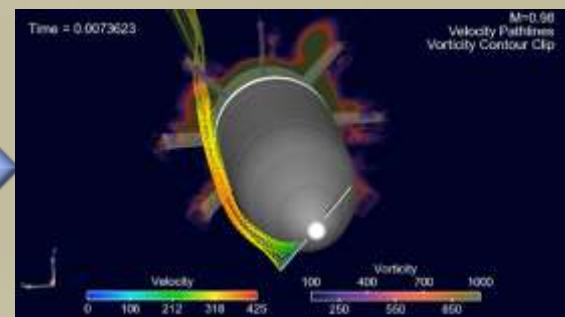
Computational Sciences



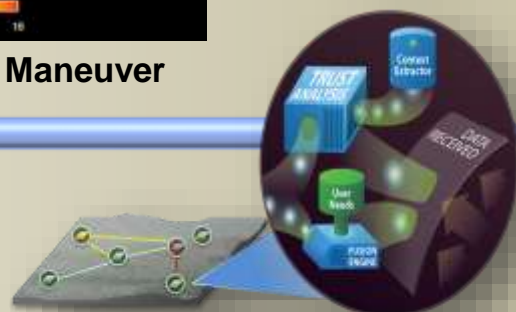
Sciences for Maneuver



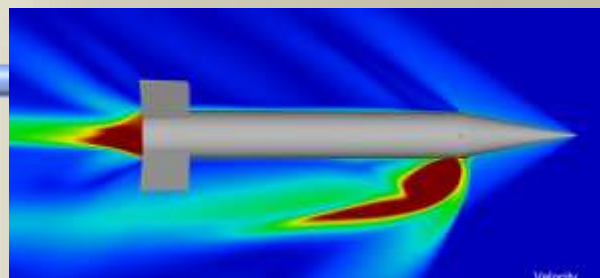
Materials Research



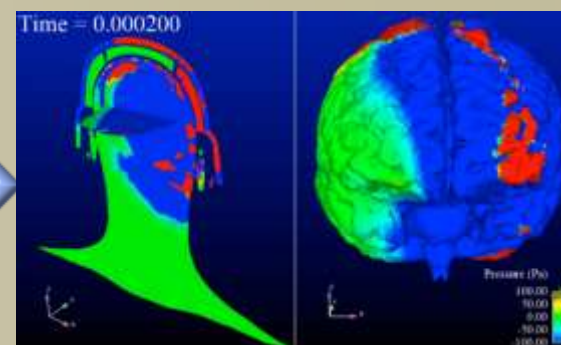
Assessment & Analysis



Information Sciences



Sciences for Lethality & Protection



Human Sciences



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Strategic Research Areas



- Tactical High Performance Computing (HPC)
- Real-time Very Large-scale Data Analytics
- Computational Predictive Design for Interdisciplinary Sciences
- Software Defined Networking for HPC
- Unconventional Computing
- Multi-Scale Modeling
- Distributed Algorithms for Quantum Networks and Quantum Control

Vision

Mobile HPC at the tactical edge optimized for mission command applications using emerging low power heterogeneous distributed computing

Impact & Relevance

- Rapid informed decision making
- Increase logistical efficiency & unit self-sufficiency

Key Research Challenges

- Power, performance, portability
- Distributed heterogeneous computing
- Cloudlet: aggregating and provisioning coupled resources (including embedded HPC)





Tactical HPC Facilities



Research Facilities include:

- Large-scale heterogeneous cluster with Xeon Phi and accelerators
- Low-power, RISC-based system
- Software Defined Networking Testbed
- 3-D architecture integration concepts
- Advanced Computing Research Center

Collaboration Opportunities:

- Novel methodologies for scalable software
- Algorithms for emerging hardware designs (qbits, neuro-synaptic, etc)
- Power optimization across a diverse spectrum of processors/cores
- Task provisioning based on architecture type and compute load



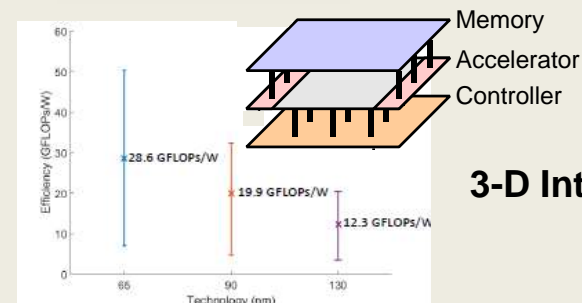
Epiphany many-core processor technology



GENI Testbed



Emulation Testbed



3-D Integrated Chip



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Large Scale Data Analytics



Vision

Provide data analytics for large scale data in real-time and time critical situations

Impact & Relevance

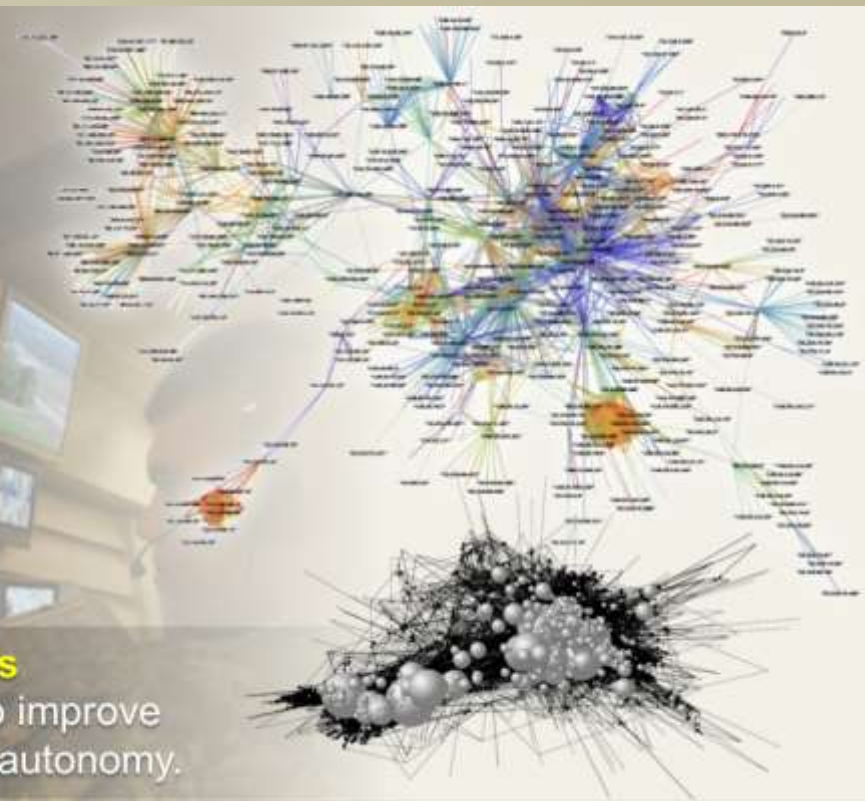
- New insights to large data sets
- Earlier and better informed materiel acquisitions

Key Research Challenges

- Multi-dimensional analytics of disparate data types
- Applying learning to volume and velocity of tactical data analytics

Understanding and exploiting large-scale, multi-dimensional, dynamic data

Develop new data-driven computational methods to analyze large-scale data in realistic timeframes to improve situational awareness, and facilitate intelligence for autonomy.





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Large Scale Data Analytics Facilities

ARL

open
campus

Research Facilities Include:

- Neuromorphic Research Laboratory
- Large-scale heterogeneous cluster with Xeon Phi and GPU
- Hadoop Cluster
- Domain specific computing architecture test bed
- ARL Supercomputing facilities

Collaboration Opportunities:

- Dynamic graph analysis for enormous datasets
- Predictive data driven algorithms
- Scalable learning and deep learning algorithms
- Visual data analytics for large data
- Streams processing of varying time-scale, varying size datasets



Big Data MPI



IBM TrueNorth



64 nodes
48 nodes Intel Phi,
16 nodes NVidia
GPUS



SDN Testbed



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Computational Predictive Design for Interdisciplinary Sciences



Vision

Scalable, novel, and optimized predictive modeling for complex multi-physics materiel systems to enhance warfighter performance

Impact & Relevance

- Holistic methods for improved lethality and protection
- Improved predictive capabilities for multi-scale modeling of weapon systems

Key Research Challenges

- Scalable models and algorithms for extreme scale computing
- Mathematical approaches for multi-scale physical models
- Uncertainty quantification



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Computational Predictive Design for Interdisciplinary Sciences Facilities



Research Facilities include:

- ARL DoD Supercomputing Resource Center
- Scientific Visualization Laboratory

Collaboration Opportunities:

- Scalable computational algorithms for complex interdisciplinary systems
- UQ based predictive design methods
- Robust approaches to validate model accuracy
- Hierarchical scale-bridging methods
- Computational additive manufacturing processes



Excalibur – Debuted at 19th fastest computer in the world
101,312 processors, 32 NVIDIA Tesla K40 GPCPUS
411 TB memory, 122 TB SSD, 3.7 Petaflops



IBM iDataPlex
20,160 cores/ 80 TB



IBM iDataPlex
17,472 cores/ 70 TB



Scientific Visualization Lab: Video Wall



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**ARL Intelligent Vehicle Systems
Research Center**



Technology Discovery & Innovation for Future Army Intelligent Unmanned Vehicles

Artificial Intelligence

- Semantic Perception
- Machine Learning
- Abstract Reasoning

Human-Machine Interaction

- Cognitive Models
- Human-Machine Communication
- Trust

Multi-Modal Control

- Distributed/Embedded
- Hybrid Mobility/Manipulation

Cognitive
Robotics Lab
at APG, MD



Free Flight Facility
at APG, MD



Micro-Systems
Wind Tunnel
at APG, MD



Indoor Experimentation Facility
at Adelphi, MD



Robotics Research Facility
at Ft. Indiantown Gap, PA



Multi-Disciplinary / Multi-Campaign

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Open Campus Supercomputing Resource



SGI ICE 8200 Ex

Cores 7,168 - 2.8 GHz Intel

Memory 21 TB

Storage 350 TB

Leverage ARL and OC expertise

- ARL Computational Sciences Research
- ARL Supercomputing Research
- DoD HPCMP Outreach
- ARL In-house Scientific Software

Network Connectivity:

atanasoff.edu (University of Maryland)



To access the ARL Open Campus System, email outreach@arl.hpc.mil



Posters



Advanced Computing Architectures

- *Emerging Computing Architectures*
- *Heterogeneous Parallel Computing*
- *ARL DoD Supercomputing Resource Center*
- *Policy Driven Programming for Software Defined Networking (SDN)*
- *Software Defined Networking (SDN) at the Optical Layer*
- *Distributed Quantum Sensor Networking (DQSN)*
- *Quantum Metadata Networking*
- *Programmable Network Research*
- *Investigation of Entanglement Dynamics*
- *Modeling Open Quantum Systems*
- *Quantum Networks: Entanglement Distribution and Applications*

Predictive Simulation Sciences

- *Computational Fluid Dynamics for Munition Aerodynamics and Flight Sciences*
- *Scalable Algorithms for Simulating Dislocations in Micro-Structured Crystals*
- *High Throughput Computational Drug Screening*
- *Model Order Reduction Methods for Large Scale Simulation Data*
- *Relaxed Linear Algebra Methods for Knowledge Discovery*
- *Methodologies for Scale-bridging in Multi-Scale Simulations*
- *Multi-scale Transport in Optical Semiconductors*
- *Large-Scale Network Data Reduction*
- *Extreme-Scale Parallel Discrete Event Simulation*
- *Real-time PF Propagation*
- *Advanced Manufacturing Process Simulation*
- *Meso- and Micro-scale Forecast Model Validation*
- *Atmospheric Boundary Layer Environment (ABLE)*

Computing Sciences

- *Computational Science for Application Domains*
- *Novel Applications for Advanced and Tactical High Performance Computing*
- *Energy Efficient Software Improvements for Constrained Devices*
- *Cloudlet-Based Processing*
- *Scientific Visualization for Large Data*
- *Developing Quantum Algorithms in HPC Environment*
- *Quantum Logic Programming*

Data Intensive Sciences

- *Autonomous Mobile High Performance Computing*
- *Real-time Data Analytics*
- *Large-Scale Network Data Reduction*
- *Neuromorphic Computing: Intelligent, Real-time Computing for Power Constrained Environments*
- *Deep Learning*
- *Rare Event Prediction with Big Data Analytics*



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Computational Science Facility Tour



Tour Highlights

- ARL DSRC Excalibur HPC System
- ARL's Root Name Server
- DREN Network Hub
- ARL's Open Campus HPC Resource
- Large Scale Data Analytics
- Advanced Computing Research Center Systems
- Software Defined Network for HPC testbed
- Tactical High Performance Computing





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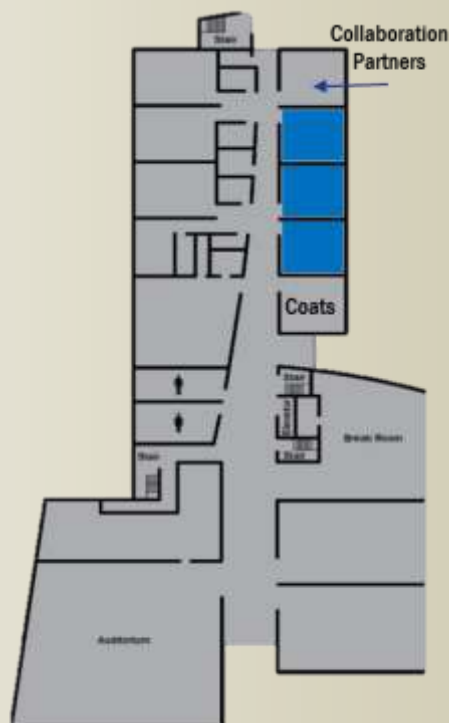
Question and Answer



Computational Sciences Campaign Poster Locations

Mallette Center First Floor

Rooms 105, 106, 107



CRADAs

CRADA Partner

CRADA Title

Adapteva Inc.	Software Programmability of 1,000 Core RISC Array Processor
Cray Computers	Next Generation Extreme Analytics Platforms
Florida International University	Tactical High Performance Computing
Missouri University of S&T	Machine Learning Systems Research and Development
University of Connecticut	Multi-scale Modeling of Materials: Identifying Damage Models for Large Data Sets
University of Southern California	Programming for Tactical High Performance Computing
Yale University	Intent Aware Programmable Network Fabrics